
**State of California
The Resources Agency
Department of Water Resources**

**MATRIX OF LIFE HISTORY AND
HABITAT REQUIREMENTS FOR
FEATHER RIVER FISH SPECIES
SP-F3.2 TASK 2**

PACIFIC LAMPREY

**Oroville Facilities Relicensing
FERC Project No. 2100**



APRIL 2004

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Governor
State of California

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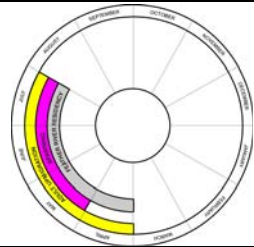
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Matrix Of Life History and Habitat Requirements for Feather River Fish Species – Pacific Lamprey
Oroville Facilities P-2100 Relicensing

Element	Element Descriptor	General	Feather River Specific
General			
common name (s)	English name (usually used by fishers and laypeople).	Pacific lamprey	
scientific name (s)	Latin name (referenced in scientific publications).	The scientific name for Pacific lamprey is <i>Lampetra tridentata</i>	
taxonomy (family)	Common name of the family to which they belong. Also indicate scientific family name.	Pacific lamprey belong to the <i>Petromyzontidae</i> family Pacific lamprey are typically larger than the other lamprey species, although dwarf landlocked populations also exist in the Klamath and Trinity rivers, and in Goose Lake in Modoc County (Moyle 2002).	
depiction	Illustration, drawing or photograph.		
range	Broad geographic distribution, specifying California distribution, as available.	Pacific lamprey are found in Pacific coast streams from Hokkaido Island, Japan, through Alaska, and down to Baja California (Moyle 2002). Pacific lamprey reportedly spawn in the upper drainages of the Sacramento-San Joaquin river system; below Nimbus Dam and above Howe Avenue on the American River; below Red Bluff Dam on the Sacramento River; in the Napa River; and in Sonoma and Walnut creeks (Wang 1986).	
native or introduced	If introduced, indicate timing, location, and methods.	Pacific lamprey are native to California (Moyle 2002).	
ESA listing status	Following the categories according to California Code of Regulations and the Federal Register, indicate whether: SE = State-listed Endangered; ST =State-listed Threatened; FE = Federally listed Endangered; FT = Federally-listed Threatened; SCE = State Candidate	Pacific lamprey are not a listed species (DFG 2002).	

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	(Endangered); SCT = State candidate (Threatened); FPE = Federally proposed (Endangered); FPT = Federally proposed (Threatened); FPD = Federally proposed (Delisting); the date of listing; or N = not listed.		
species status	If native, whether: Extinct/ extirpated; Threatened or Endangered; Special concern; Watch list; Stable or increasing. If introduced, whether: Extirpated (failed introduction); highly localized; Localized; Widespread and stable; Widespread and expanding.	Pacific lamprey are native to California and currently on a status "Watch List" (Moyle 2002). In Oregon, the Pacific lamprey was listed as a sensitive species in 1993, followed with protected status in 1996 (Bayer et al. 2001; Close et al. 2002).	
economic or recreational value	Indicate whether target species sought for food or trophy. Whether desirable by recreational fishers, commercial fishers, or both.	Lampreys reportedly have low economic or recreational value (Moyle 2002). Lampreys reportedly have high cultural value to Native Americans (Close et al. 2002).	
warmwater or coldwater	Warmwater if suitable temperature range is similar to basses; coldwater if suitable temperature range is similar to salmonids.		
pelagic or littoral	Environment: Pelagic - living far from shore; Littoral - living near the shore.	Pacific lamprey are anadromous and spend their predatory phase in the oceans, except for some landlocked populations found in the Klamath and Trinity rivers and in Goose Lake (Moyle 2002). Although Pacific lamprey can reportedly wander to the open oceans, it is very likely that they do not stray far from the mouths of their home spawning streams, because their prey is most abundant in estuaries and other coastal areas (Moyle 2002).	
bottom or water column distribution	Environment: bottom (benthic) or along water column.		
lentic or lotic	Environment: Lentic - pertaining to stagnant water, or lake-like; Lotic - moving water, or river-like.	Pacific lamprey typically construct nests and reproduce in lotic environments (Russell and Beamish 1987).	

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		Pacific lamprey were reportedly observed within two regions of the Babine Lake system in British Columbia, spawning in shallow lentic water (Russell and Beamish 1987).	
Adults			
life span	Approximate maximum age obtained.	Pacific lamprey reportedly live between 6 and 10 years from the larval stage to the spawning phase; of this total, 4 to 6 years are spent in the larval phase/metamorphosis and 20 to 40 months are spent in the parasitic phase in the ocean (Close et al. 2002).	
adult length	Indicate: Length at which they first reproduce; average length and maximum length the fish can attain.	As reported, the maximum adult length of Pacific lamprey is 15.7 inches (40 centimeters). Other lamprey species reportedly cannot reach this size (Moyle 2002). The reported length of Pacific lamprey ranges from 11.8 to 29.9 inches (30 to 76 centimeters) (Moyle 2002). Transforming and newly transformed adult Pacific lamprey reportedly are 6.7 inches (17 centimeters) in length (Wang 1986).	
adult weight	Indicate: Weight at which they first reproduce; average weight and maximum weight the fish can attain.		
physical morphology	General shape of the fish: elongated, fusiform, laterally compressed, etc.	Pacific lamprey are elongated and eel-like in shape (Moyle 2002).	
coloration	Indicate color, and color changes, if any, during reproduction phase.	Spawning adult Pacific lamprey are dark greenish-black dorsally and have a paler golden color on the belly. In Goose Lake, they may be shiny bronze in color as well. Newly metamorphosed Pacific lamprey are silvery in color (Moyle 2002).	
other physical adult descriptors	Unique physical features for easy identification.	Pacific lamprey have sharp, horny plates (teeth) in all areas of the sucking disc, more than in any other California lamprey (Moyle 2002).	
adult food base	Indicate primary diet components.	The Pacific lamprey diet reportedly includes a wide variety of fishes, including salmon and flatfish (Moyle 2002). During the oceanic phase, Pacific lamprey parasitize on various fish species and whales (Close et al. 2002).	

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adult feeding habits	Indicate whether plankton eater, algae eater, bottom feeder, piscivorous, active hunter, ambush predator, filter feeder. Night, day, dusk or dawn feeder.	Pacific lamprey attack ventrally and anteriorly, leaving 0.39 to 1.2 inch (1 to 3 centimeter) holes in the flesh. They remain attached to a host for varying periods that last up to several days (Beamish 1980).	
adult in-ocean residence time	For anadromous species, age when they migrate to the ocean and duration spent in the ocean before returning to freshwater to spawn.	Pacific lamprey reportedly reside in the ocean during the parasitic phase, which lasts approximately 3.5 years in British Columbia and 20 to 40 months in Oregon (Close et al. 2002). Pacific lamprey reportedly remain in saltwater for 3.5 years, in contrast to river lamprey who remain in saltwater for 3 to 4 months (Beamish 1980).	
adult habitat characteristics in-ocean	For anadromous species, description of the ocean habitat utilized: whether along major current systems, gyres, pelagic (beyond continental shelves) and neritic (above continental shelves) zones, etc.	Lampreys within the Strait of Georgia were reportedly most abundant near the surface during July (Beamish 1980).	
Adult upstream migration (immigration)			
range of adult upstream migration timing	Time of year adults migrate upstream. If applicable, indicate for various runs.	As reported, adult Pacific lampreys usually move up into spawning streams from January through June. In northern streams, upstream movement occurs through July. In the Trinity River, upstream movement was observed in August and September. It is possible that there are two distinct upstream runs in the Klamath River: a spring run that spawns immediately, and a fall run which holds over and spawns the following spring (Moyle 2002). Upstream movement of Pacific lamprey reportedly takes place at night. Although Pacific lamprey prefer high flows, they can migrate under a wide range of flows, from 82 to 5,577 cubic feet per second (25 to 1,700 cubic meters per second). Pacific lamprey are reportedly known to migrate more than 273 miles (440 kilometers) from salt water (Moyle 2002). Pacific lamprey reportedly enter freshwater in April	

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Element	Element Descriptor	General	Feather River Specific
		through June. By September, upstream migration of Pacific lamprey is complete. Pacific lamprey overwinter in freshwater and spawn in the spring the following year (Bayer et al. 2001; Beamish 1980; Close et al. 2002). In British Columbia, Pacific lamprey reportedly return to freshwater in April through June (Beamish 1980).	
peak adult upstream migration timing	Time of year most adults migrate upstream. If applicable, indicate for various runs.	The upstream migration of adult Pacific lamprey reportedly takes place from May through June (Moyle 2002). The upstream migration of adult Pacific lamprey reportedly takes place from mid-April through July (Close 2001).	
adult upstream migration water temperature tolerance	Range of water temperatures allowing survival. Indicate stressful or lethal levels.	Reported water temperature extremes in which migrating adult Pacific lamprey can survive range from 41.9°F to 59.9°F (5.5°C to 15.5°C), as observed under laboratory conditions (Close 2001).	
adult upstream migration water temperature preference	Range of suitable, preferred or reported optimal water temperatures. Indicate whether literature, observational, or experimental.	As observed under laboratory conditions, migrating adult Pacific lamprey reportedly prefer water temperatures of approximately 54.5°F (12.5°C) for reproduction (Close 2001).	
Adult holding (freshwater residence)			
water temperature tolerance for holding adults	Range of water temperatures allowing survival. Indicate stressful or lethal levels.	Suitable water temperatures for Pacific lamprey during the winter months in John Day Reservoir reportedly range from 39.2°F to 42.8°F (4°C to 6°C) (Close 2001).	
water temperature preference for holding adults	Range of suitable, preferred or reported optimal water temperatures. Indicate whether literature, observational, or experimental.	The water temperatures that holding adult Pacific lamprey prefer for growth and reproduction reportedly range from 41.9°F to 54.5°F (5.5°C to 12.5°C) (Close 2001).	
water depth range for holding adults	Reported range of observed (minimum and maximum) water depth utilization.	Reported water depths for holding adult Pacific lamprey range from 1.6 to 34.1 feet (0.5 to 10.4 meters) (Bayer et al. 2001).	
water depth preference for holding adults	Reported range of most frequently observed water depth utilization.	The water depth preference for holding Pacific lamprey adults was reportedly found to be 3.0 feet (0.9 meter) (Bayer et al. 2001).	
substrate preference for holding adults	If bottom dwellers, indicate substrate: mud, sand, gravel, boulders, aquatic plant beds, etc. If gravel, indicate	Adult Pacific lamprey reportedly hide near stones and logs for several months to a year until fully mature (Moyle 2002).	

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Element	Element Descriptor	General	Feather River Specific
	range or average size of gravel.	Pacific lamprey reportedly overwinter predominantly under boulders [greater than 9.8 inches (25 centimeters)], in riffle/glide habitats, and also in cobbles [1.9 to 9.8 inches (5 to 25 centimeters)] (Bayer et al. 2001).	
water velocity range for holding adults	Reported range of observed (minimum and maximum) water velocity utilization.	The velocity for holding Pacific lamprey adults reportedly ranges from 0.07 to 4.0 feet per second (0.02 to 1.22 meters per second) (Bayer et al. 2001).	
water velocity preference for holding adults	Reported range of most frequently observed water velocity utilization.	The median water velocity for holding adult Pacific lamprey is reportedly around 1.2 feet per second (0.37 meters per second) (Bayer et al. 2001).	
other habitat characteristics for holding adults	General description of habitat (e.g. turbid or clear waters, lentic or lotic, presence of aquatic plant beds, debris, cover, etc.).	In the John Day River basin, Pacific Lamprey considered to be holding through the winter were reportedly nearly always found in substrates comprised mostly of boulders (Bayer et al. 2001).	
timing range for adult holding	Time of year (earliest-latest) and duration of stay from upstream migration to spawning.	Adult Pacific lamprey reportedly hold from several months to one year before fully maturing and spawning (Beamish 1980; Moyle 2002). Over-wintering of adult Pacific lamprey reportedly occurs within the John Day River basin from mid-September to mid-March (Bayer et al. 2001).	
timing peak for adult holding	Time of year when maximum number of adults are present before spawning.	In the Santa Clara River, the first movements of Pacific lamprey reportedly occur after the winter rains breach the sand bar blocking the lagoon at the mouth in January, February, or March (Moyle 2002).	
Spawning			
fecundity	Average or range in the number of eggs females lay in a spawning season.	Female Pacific lamprey reportedly lay 20,000 to 200,000 eggs in one spawning season (Moyle 2002). In Oregon, Pacific lamprey females reportedly lay 98,000 to 238,000 eggs in a spawning season (Close et al. 2002).	
nest construction	Location and general description of nest -- substrates, aquatic plants, excavations, crevices, habitat types, etc.	Crude Pacific lamprey nests are constructed in gravelly areas (Moyle 2002).	

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Element	Element Descriptor	General	Feather River Specific
nest size	Size and average dimensions of the nest.	Pacific lamprey nest sizes reportedly range from 13 to 24 inches (35 to 60 centimeters) in diameter (Moyle 2002).	
spawning process	Indicate whether nest builder, broadcast spawner, or other.	Pacific lamprey are nest builders (Moyle 2002).	
spawning substrate size/characteristics	Range of substrates used during spawning (e.g. mud, sand, gravel, boulders, beds of aquatic plants). Indicate presence of plant/wood debris, crevices at spawning sites. If gravel, indicate range of average size.	Substrates used during Pacific lamprey spawning can include gravel, silt covered cobbles, and rocky riffle areas (Moyle 2002). Substrates used during Pacific lamprey spawning include gravel, rocks, and occasionally sand (Beamish and Northcote 1989; Wang 1986).	
preferred spawning substrate	Indicate preferred spawning substrate (e.g. mud, sand, gravel, boulders, plant bed, etc).	The preferred Pacific lamprey spawning substrate appears to be gravelly areas (Moyle 2002). Pacific lamprey generally spawn on sand and gravel (lotic environment), but were also observed spawning in stagnant and muddy (lentic) environments (Whyte et al. 1993).	
water temperature tolerance for spawning	Range of water temperatures allowing survival. Indicate stressful or lethal levels.	The water temperature range for Pacific lamprey spawning is reported at 53.6°F to 64.4°F (12 to 18°C) (Moyle 2002). The reported water temperature range for Pacific lamprey spawning is 55.4°F to 65.3°F (13 to 18.5°C) (Wang 1986).	
water temperature preference for spawning	Range of suitable, preferred or reported optimal water temperatures. Indicate whether literature, observational, or experimental derivation.	The reported optimal temperature for Pacific lamprey spawning is approximately 59°F (15°C) (Wang 1986).	
water velocity range for spawning	Minimum and maximum speed of water current the spawning fish can tolerate.	The reported water velocity for Pacific lamprey spawning ranges from 0.79 to 2.8 feet per second (0.24 to 0.84 meters per second) (Moyle 2002). Pacific lamprey spawning generally takes place in moderate to swift currents (lotic environment), but is also observed spawning in stagnant, muddy (lentic) environments (Whyte et al. 1993).	

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Element	Element Descriptor	General	Feather River Specific
water velocity preference for spawning	Preferred water current (flow velocity) during spawning.	The preferred water velocity during Pacific lamprey spawning is reported to be 2.1 feet per second (0.64 meters per second) (Moyle 2002).	
water depth range for spawning	Reported range of observed (minimum and maximum) water depth utilization.	The reported water depth range where Pacific lamprey spawning takes place is 11.8 to 59.1 inches (30 to 150 centimeters) (Moyle 2002).	
water depth preference for spawning	Reported range of most frequently observed water depth utilization.	The reported mean depth observed for Pacific lamprey spawning was 23.2 inches (59 centimeters) (Moyle 2002).	
range for spawning timing	Earliest and latest time of season or year in which spawning occurs.	In Oregon, Pacific lamprey spawning reportedly occurs in May through July, when water temperatures reach 50°F to 59°F (10°C to 15°C) (Close et al. 2002). In British Columbia, Pacific lamprey spawning reportedly occurs in April through June, and possibly into July (Beamish 1980).	
peak spawning timing	Time of year most fish start to spawn.	Peak spawning of Pacific lamprey appears to occur in the spring. In the Klamath River, there may be two distinct runs; a spring run that spawns immediately, and a fall run that holds over and spawns the following spring (Moyle 2002).	
spawning frequency (iteroparous/semelparous)	Semelparous - producing all offspring at one time, such as in most salmon. Usually these fish die after reproduction. Iteroparous - producing offspring in successive, e.g., annual or seasonal batches, as is the case in most fishes.	Generally Pacific lamprey spawn once in a lifetime, although it is speculated that some may survive the first spawn and spawn again the next year (Moyle 2002). Spawning Pacific lamprey reportedly die within 3 to 36 days after spawning (Close et al. 2002).	
Incubation/early development			
egg characteristics	Shape, size, color, in clusters or individuals, stickiness, and other physical attributes.	Pacific lamprey eggs are oval in shape, although slightly elliptical and irregular. The yolk is creamy yellow to pale green, and the eggs are adhesive (Wang 1986).	
water temperature tolerance for incubation	Range of water temperatures allowing survival. Indicate stressful or lethal levels.	Pacific lamprey eggs reportedly appeared to survive in temperatures ranging from 50°F to 64.4°F (10 to 18°C) under laboratory conditions. At 71.6°F (22°C), Pacific lamprey egg survival dropped significantly (Meeuwig et al. 2002).	
water temperature	Range of suitable, preferred or	The reported optimum temperature for Pacific lamprey	

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preference for incubation	reported optimal water temperatures. Indicate whether literature, observational, or experimental derivation.	incubation is 59°F (15°C) (Moyle 2002).	
time required for incubation	Time duration from fertilization to hatching. Note: Indicate at which temperature range. Incubation time is temperature-dependent.	Reported incubation time for Pacific lamprey was 19 days at 59°F (15°C) (Moyle 2002).	
size of newly hatched larvae	Average size of newly hatched larvae.	The reported length of newly hatched Pacific lamprey larvae ranges from 0.16 to 0.20 inches (4 to 5 millimeters) (Wang 1986).	
time newly hatched larvae remain in gravel	Time of year of hatching, and duration between hatching and emergence from gravel.	Hatching Pacific lamprey ammocoetes spend a short time in nest gravel (Moyle 2002).	
other characteristics of larvae	Alevin -- early life history phase just after hatching (larva) when yolk-sac still present.	Pacific lamprey larvae eventually swim up into the current and are washed downstream to a suitable area of soft sand and mud (Moyle 2002). Pacific lamprey larvae burrow into soft sediments in shallow areas along stream banks (Close et al. 2002).	
timing range for emergence	Time of year (earliest-latest) hatchlings (larvae and alevins) leave or emerge from the nesting/hatching (gravel) sites.	The downstream migration of Pacific lamprey begins during high outflow events in winter and spring (Moyle 2002).	
timing peak for emergence	Time of year most hatchlings emerge.	Within the John Day River, the majority of the Pacific lamprey larvae were collected between July and September (Close 2001).	
size at emergence from gravel	Average size of hatchlings at time of emergence.	Reported average size of Pacific lamprey larvae at the time of emergence in the John Day River was 2.48 inches (63.1 millimeters) (Close 2001).	
Juvenile rearing			
general rearing habitat and strategies	General description of freshwater environment and rearing behavior.		
water temperature tolerance for juvenile rearing	Range of water temperatures allowing survival. Indicate stressful or lethal levels.	As observed under laboratory conditions, Pacific lamprey survival drops significantly at water temperatures above 71.6°F (22°C) (Meeuwig et al. 2002).	
water temperature	Range of suitable, preferred, or	The water temperature range for juvenile growth of	

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preference for juvenile rearing	reported optimal water temperatures. Indicate whether literature, observational, or experimental derivation.	Pacific lamprey is 50°F to 64.4°F (10°C to 18°C), as observed in laboratory conditions (Meeuwig et al. 2002).	
water velocity ranges for rearing juveniles	Reported range of observed (minimum and maximum) water velocity utilization.	Juvenile Pacific lamprey can reportedly tolerate flows of 0.66 to 1.31 feet per second (20 to 40 centimeters per second) (Close 2001).	
water velocities preferred by rearing juveniles	Reported range of most frequently observed water velocity utilization.	Water velocities preferred by rearing juvenile Pacific lamprey reportedly range from 0.66 to 0.98 feet per second (20 to 30 centimeters per second) (Close 2001).	
water depth range for juvenile rearing	Reported range of observed (minimum and maximum) water depth utilization.		
water depth preference for juvenile rearing	Reported range of most frequently observed water depth utilization.		
cover preferences for rearing juveniles	Type of cover for protection from predators used by rearing juveniles (e.g. crevices, submerged aquatic vegetation, overhanging vegetation, substrate cover, undercover bank, small woody debris, large woody debris).	Metamorphosing Pacific lamprey reportedly move from muddy habitat in lentic waters to silt covered large gravel [0.39 to 1.6 inches (1 to 4 centimeters) in diameter] in moderate currents (Beamish 1980).	
food base of juveniles	Indicate primary diet components. Also indicate the diet changes, if any, as growth occurs.	During the ammocoete stage, juvenile Pacific lamprey feed on organic matter and algae off the surfaces of substrates (Moyle 2002).	
feeding habits of rearing juveniles	Indicate whether plankton eater, algae eater, bottom feeder, piscivorous, active hunter, ambush predator, filter feeder. Night, day, dusk or dawn feeder. Also indicate change of feeding habits growth occurs.	During the ammocoete stage, juvenile Pacific lamprey feed by sucking on organic matter and algae off the surfaces of substrates (Moyle 2002).	
predation of juveniles	Indicate which species prey on juveniles.	Coho salmon and smallmouth bass prey on emergent larval Pacific lamprey (Close et al. 2002).	
timing range for juvenile rearing	Range of time of year (months) during which rearing occurs.	Pacific lamprey ammocoetes reportedly metamorphose in July through October before downstream migration (Beamish 1980).	

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timing peak for juvenile rearing	Time of year (months) during which most rearing occurs.	Pacific lamprey metamorphose in late July (Beamish 1980).	
Juvenile emigration			
time spent in fresh water prior to emigrating	Duration (in years and/or months) from emergence to emigration to the ocean.	The reported length of the Pacific lamprey ammocoetes stage is uncertain, but probably lasts 5 to 7 years (Moyle 2002).	
water temperature tolerances during emigration	Range of water temperatures allowing survival. Indicate stressful or lethal levels.		
water temperature preferences during emigration	Range of suitable, preferred or reported optimal water temperatures. Indicate whether literature, observational, or experimental derivation.		
emigration timing range	Time of year juveniles commence emigration and duration of emigration.	Downstream emigration of juvenile Pacific lamprey begins when their metamorphosis is completed; during high flow events in winter and spring, perhaps coincident with the upstream migration of adults (Moyle 2002). Pacific lamprey emigration occurs during the fall through the following spring. The exact timing depends on environmental conditions (Close et al. 2002).	
emigration timing peak	Time of year most juveniles are emigrating.	Pacific lamprey emigration peaks during winter and spring (Moyle 2002). In British Columbia, a reported 99 percent of metamorphosed lampreys migrated downstream in April through May (Close et al. 2002).	
size range of juveniles during emigration	Minimum and maximum sizes (inches or mm) of emigrating juveniles. Indicate average size.	Ammocoetes reportedly reach 5.5 to 6.3 inches (14 to 16 centimeters) before they start the metamorphosis to young adults (Moyle 2002).	
factors associated with emigration	Pulse flows, water temperature changes, turbidity levels, photoperiod, etc.		
Other potential factors			
DO	Levels of dissolved oxygen in water expressed in mg/l tolerated by fish.		

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pH	Alkalinity/acidity of water (expressed in pH) that fish can tolerate.		
turbidity	Indicate turbidity or state of water (e.g., clear water or presence of siltation or organic/inorganic matter in water) that fish can tolerate.	Pacific lamprey in the advanced stages of metamorphosis characteristically were found within gravel or boulder substrates where currents were moderate to strong (Beamish 1980).	
factors contributing to mortality	e.g., fishing/angling mortality, drastic habitat alterations, unfavorable climatic changes, etc.	<p>Pacific lamprey have the ability to surmount barriers during upstream migration (Moyle 2002).</p> <p>Pacific lamprey populations have been eliminated from many urbanized streams and are usually absent in highly altered or polluted streams (Moyle 2002).</p> <p>Causes of Pacific lamprey decline may include: 1) flow regulation, which can impede passage at dams and dewater rearing habitat; 2) river channelization, which can negatively impact larvae habitat by increasing water velocity and reducing depositional areas; and 3) susceptibility to the toxicological effects from contaminants due to their sedentary life (Close et al. 2002).</p> <p>Pacific lamprey endogenous food reserves during metamorphosis and spawning enable them to survive environmental catastrophes, and allow them to migrate considerable distances to spawning areas (Whyte et al. 1993).</p> <p>Despite a reportedly relatively high resilience, the Pacific lamprey does not have the ability to establish landlocked populations (Beamish and Northcote 1989; Whyte et al. 1993).</p>	

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